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Short communication

The earliest tiger beetle from the Lower Cretaceous of China (Coleoptera: Cicindelinae)

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ABSTRACT

Fossil tiger beetles (Carabidae: Cicindelinae) are extremely rare, and little is known about their early evolutionary history. Here we report the earliest known tiger beetle, *Cretotetracha grandis* gen. et. sp. nov., from the Lower Cretaceous Yixian Formation (lower Aptian) of China. C. *grandis* bears several features characteristic of the subtribe Megacephalina, including a large body with total length/width ratio 2.3:1; labium transverse, without median tooth; eyes large; eyes and head together wider than the thorax; prothorax noticeably narrower than elytra; anterior corners of pronotum noticeably more extended anteriorly than anterior margin of prosternum. It represents the second definite Mesozoic record of Cicindelinae, and extends the further lineage back into the Early Cretaceous.

1. Introduction

The Cicindelinae (tiger beetles) is a large familiar group of beetles, with approximately 130 genera and 2000 species (Ball, 2000; Cassola and Pearson, 2000; Arndt et al., 2005; Pearson et al., 2006). The present day distribution of cicindelines is worldwide except for Tasmania, Antarctica, and remote oceanic islands (Pearson, 1988; Cassola and Pearson, 2000). Adult cicindelines, ranging from 6 to 70 mm in length, often have large bulging eyes, long, slender legs and sickle-shaped mandibles, and are efficient visual predators occurring on open substrates where they forage on a wide variety of small arthropods including insects, spiders, and small terrestrial crustaceans (Arndt et al., 2005; Pearson et al., 2006). Many species are brilliantly coloured while others are camouflaged, blending in with their habitat (Pearson, 1988). Their beauty, diversity, and fearsome behaviour make them a favorite among collectors worldwide (Pearson et al., 2006). Furthermore, this group is an important component of the ecosystem, and provides excellent models to study ecology, physiology, behaviour, phylogeny, and biogeography (e.g., Pearson, 1988; Pearson and Vogler, 2001; Barraclough and Vogler, 2002; Galián et al., 2007; López-López et al., 2012, 2013), thus making it one of the best studied insect groups.

Fossil Cicindelinae are very important for understanding their early evolution by providing valuable information such as times of divergences and extinctions. But the fossil Cicindelinae are extremely rare (Pearson, 1988; Roschmann, 1999; Cassola and Werner, 2004). The Cenozoic fossil record has been reviewed by Nagano et al. (1982) and Cassola and Werner (2004). Only two Mesozoic Cicindelinae fossils were reported, and both are from the Lower Cretaceous Crato Formation (upper Aptian) of Brazil (Cassola and Werner, 2004; Wolf-Schwenninger and Schawaller, 2007). *Oxycheilopsis cretacicus* Cassola and Werner, 2004, was erected based on a complete specimen, and was attributed to the subtribe

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Oxycheilina (Cassola and Werner, 2004). The other specimen, however, *Alexcarabus megagnathus* Martins-Neto, 2002, probably belongs to the family Trachypachidae (Kirejtshuk and Ponomarenko, 2013). In addition, Cicindelinae from the Lower Cretaceous of Liaoning, China were mentioned by Kirejtshuk et al. (2010), but these fossils require formal description. Thus, only one Mesozoic specimen can be confidently attributed to the Cicindelinae.

In this paper, we report and characterize the earliest known unambiguous fossil cicindeline (subtribe Megacephalina) from the Lower Cretaceous (lower Aptian) of China.

2. Material and methods

The specimen was collected from the Lower Cretaceous Yixian Formation of Yangshuwanzi Village, Bisiyingzi Township, Ningcheng County, Chifeng City, Inner Mongolia, China (Fig. 1). The Lower Cretaceous Yixian Formation, widespread in western Liaoning, northern Hebei and southern Inner Mongolia, is very famous for yielding some of the earliest angiosperms, feathered dinosaurs, primitive birds and mammals, and abundant well-preserved insects (Zhang et al., 2010). The age of the Yixian Formation is restricted to ca. 129.7-122.1 Ma (Barremian–early Aptian), and the insect-bearing horizon is thought to be the Jianshangou bed (ca.124-122.5 Ma; early Aptian) of the Yixian Formation (Chang et al., 2009; Zhang et al., 2010). Both the Yangshuwanzi and Liutiaogou fossil localities yield abundant fossil beetles dominated by a variety of scarabs (Wang et al., 2012). The fossils from Yangshuwanzi are preserved in grey or yellow silty mudstone, while rocks from Liutiaogou are sometimes thinner and more fragile.

The specimen was examined dry and under alcohol, using a Nikon SMZ1000 stereomicroscope and drawings were made with the aid of a camera lucida. The photographs were prepared using a digital camera (DXM1200) connected to the above stereomicroscope, and the line drawings were readjusted on photographs using image-editing software (CorelDraw 14.0 and Adobe Photoshop CS). In drawings, dotted lines denote hidden or faintly seen parts. Body length was measured along the midline from the apex of the labrum to the apex of the elytra, and width was measured across the broadest part of elytra. The specimen is deposited in the Nanjing Institute of Geology and Palaeontology (NIGP), Chinese Academy of Sciences.

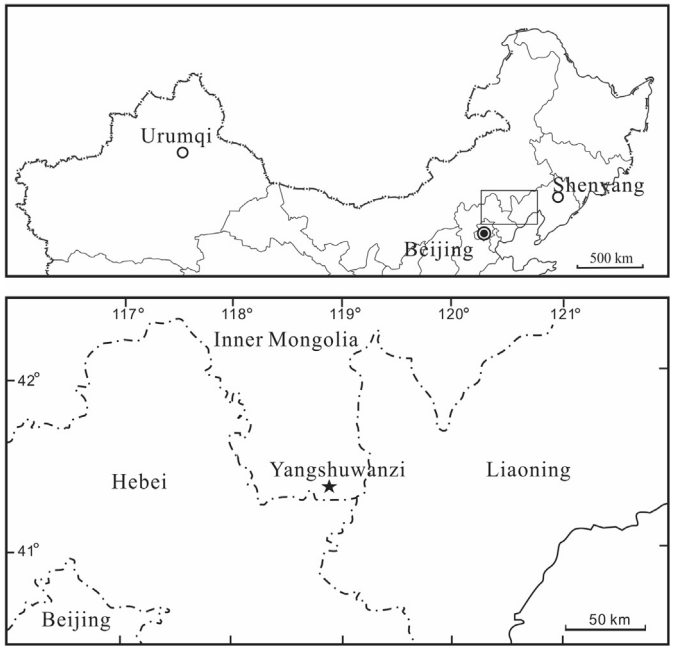

Fig. 1. Map showing the fossil locality, Yangshuwanzi Village, Bisiyingzi Township, Ningcheng County, Chifeng City, Inner Mongolia, China.FTAB.

3. Systematic palaeontology

We follow the phylogenetic conclusion of Pearson and Vogler (2001) in which the Cicindelinae are arranged here in five tribes: Amblycheilini, Manticorini, Megacephalini, Collyridini, and Cicindelini. Terms and abbreviations for mandibles follow Ball et al. (2011).

Order Coleoptera Linnaeus, 1758
Family Carabidae Latreille, 1802
Subfamily Cicindelinae Latreille, 1802
Megacephalini Laporte, 1834
Subtribe Megacephalina Laporte, 1834

Genus ***Cretotetracha*** gen. nov.

Derivation of name. The generic name is after the period 'Cretaceous', and the genus *Tetracha* Hope, 1838; gender neuter.
Type species. Cretotetracha grandis gen. et. sp. nov.; by original designation.
Type horizon and locality. Lower Cretaceous Yixian Formation (lower Aptian); Yangshuwan Village, Chifeng City, Inner Mongolia, China.
Diagnosis. Medium body with total length/width ratio 2.3:1. Head with large eyes. Labium transverse, without median tooth. Mandibles sickle-shaped, with an apical tooth, two terebral (incisor) teeth. Pronotum transverse, with length/width ratio 1.5:1; anterior corners noticeably extended; base distinctly narrower than width of elytral base. Abdomen as long as meso- and metasternum together; apex of abdomen rounded. Legs long, metatibiae slightly longer than femora.

Cretotetracha grandis gen. et. sp. nov.
(Figs. 2–3)

Derivation of name. Specific epithet is from Latin *grandis* referring to the large body.
Holotype. NIGP154997, a well-preserved beetle in ventral aspect. From Yangshuwanzi Village, Bisiyingzi Township, Ningcheng County, Chifeng City, Inner Mongolia, China.
Diagnosis. As for the genus.
Description. The holotype is an almost complete adult in ventral aspect (Fig. 2). Body medium, length 18.2 mm, width 8.0 mm. Head and pronotum comparatively short, about two-fifths of body length. Head length (including mandibles) 5.3 mm, occiput width 4.6 mm. Length of head (including mandibles) 1.2 times as long as occiput width. Head capsule narrowing anteriorly from base. Eyes large, convex, a little longer than temples. Antennae inserted at anterior margin of eyes; scape dilated; pedicellum short; first flagllomere slender, slightly longer than scape. Labium distinctly transverse, without median tooth, probably with submarginal setae. Right mandible approximately 4.2 mm long, left mandible approximately 3.3 mm long, large, slightly incurved, with an apical tooth, two small terebral (incisor) teeth. Maxillary palps longer than mandibles (Fig. 3).

Pronotum transverse, length 4.3 mm, maximal width 8.0 mm, 1.9 times as wide as long, widest nearly in the middle; anterior corners noticeably extended; base distinctly narrower than width of elytral base. Prosternum before procoxae 1.2 times longer than procoxae. Prosternal process narrow, as long as procoxae. Mesepimeron short, extending to mesocoxal cavities, slightly widened laterally.

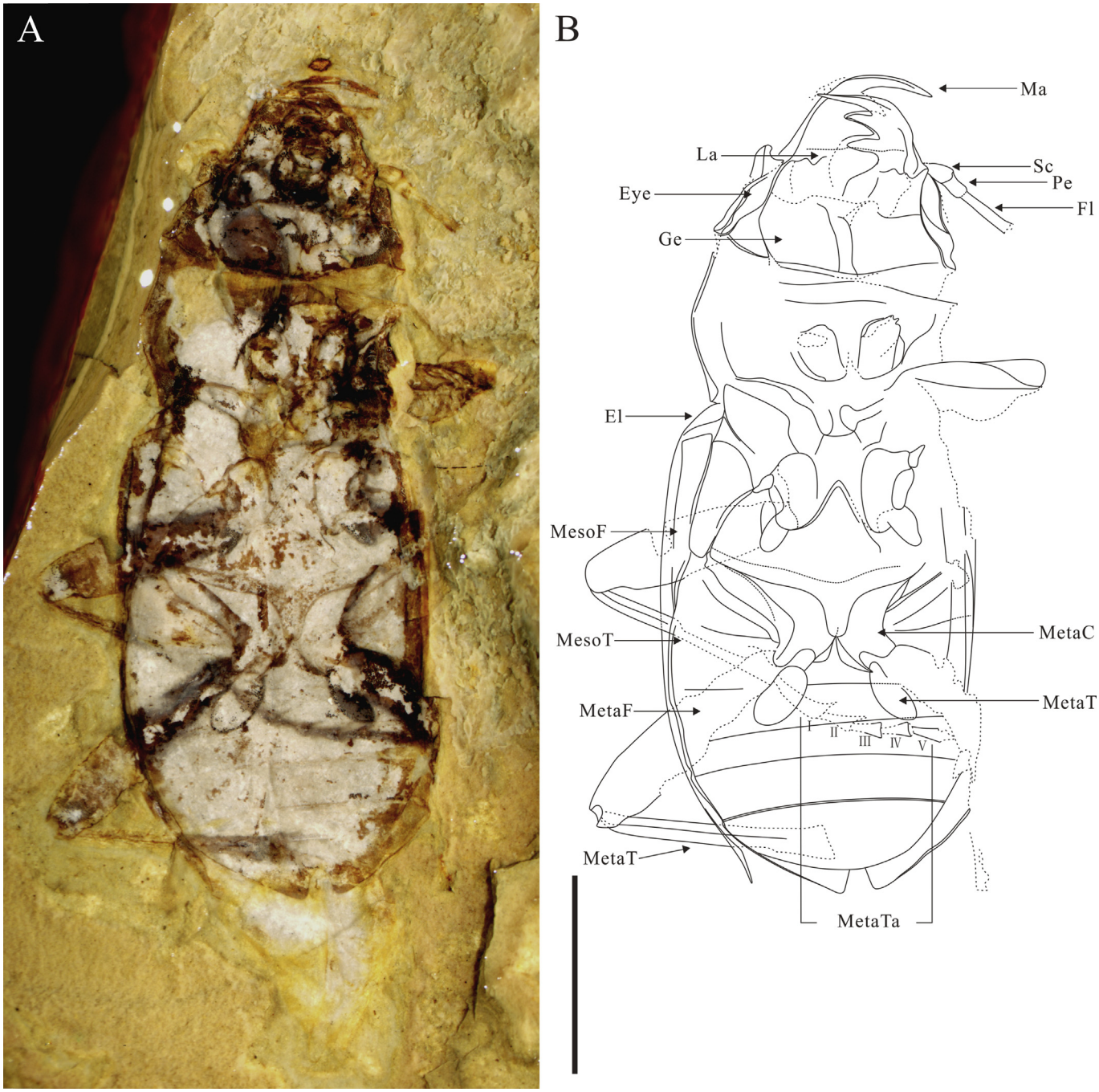

Fig. 2. *Cretotetracha grandis* gen. et. sp. nov., photograph and line drawing of holotype NIGP154997, from the Lower Cretaceous Yixian Formation of Liutiaogou. Scale bar represents 5 mm. Ma, mandible; La, labium; Sc, scape; Pe, pedicel; Fl, flagellum; Ge, gena; El, elytron; ProC, procoxa; MesoC, mesocoxa; MesoF, mesofemur; MesoT, mesotibia; MetaC, metacoxa; MetaF, metafemur; MetaT, metatibia; MetaTa, metatarsus.

Metasternum short; distance between meso- and metacoxae almost as long as mesocoxal length. Metepisterna subtriangular, gradually widened anteriorly. Metacoxae oblique, slightly projecting over abdomen, twice as wide as long. Metacoxal plates slightly longer than coxae, tapering laterally in middle. Abdomen length 8.1 mm, as long as meso- and metathorax together, widened from base to apex of sternum III, then narrowing. Sterna II, III, IV, VI subequal in length; sternum V shortest; last one (sternum VII) approximately twice as long as the preceding one; last sternum subtriangular, 3 times as wide as long. Elytra length 12.4 mm.

Femora uniformly thickened; metafemora 1.1 times as long as mesofemora. Mesotibiae and metatibiae slender, widened apically. Mesotibial length 5.1 mm, slightly longer than mesofemora. Tarsus length I 1.57 mm, II 1.04 mm, III 0.83 mm, IV 0.82 mm, V 0.73 mm. Metatrochanters nearly one-fourth as long as metafemora. Mesotibial length 6.3 mm, slightly longer than metafemora.

4. Discussion

The new specimen undoubtedly belongs to the subfamily Cicindelinae as shown by the combination of the following characters: long, sickle-shaped mandibles; simple teeth arranged along the inner side of the mandible; antennae attached to the head between the eye and base of the eyes mandibles; long body form

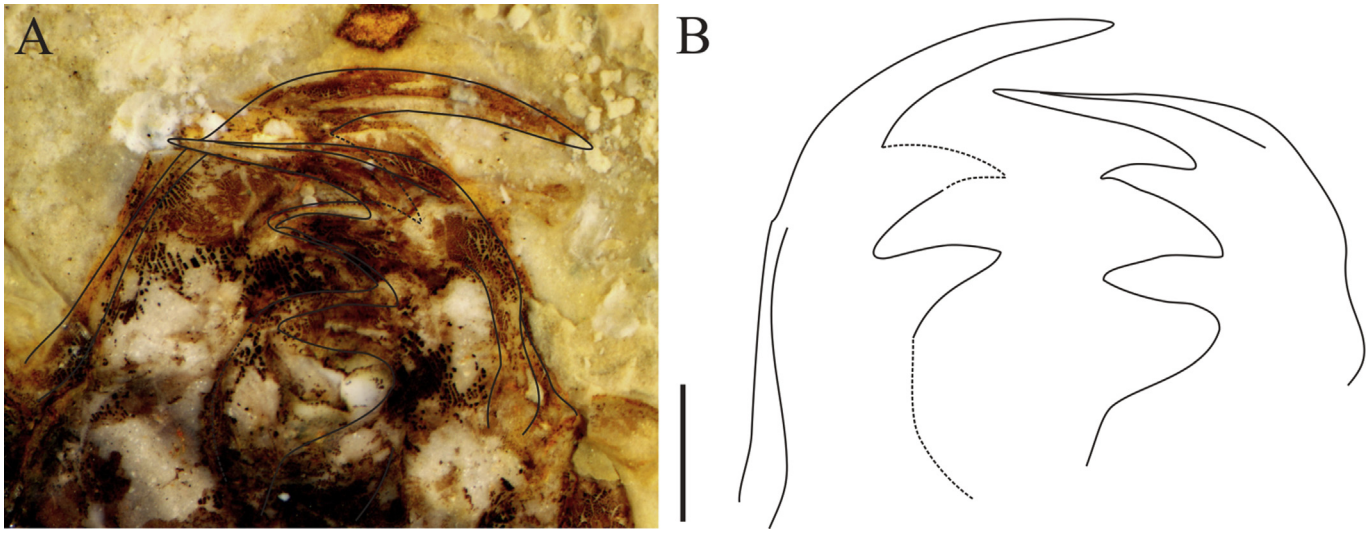

Fig. 3. *Cretotetracha grandis* gen. et. sp. nov., holotype NIGP154997. A, mouthparts in ventral aspect (with line drawing of mandibles); B, line drawing of mandibles in ventral aspect. Scale bar represents 1 mm.

with eyes and head together wider than the thorax; long, thin running legs (Pearson et al., 2006). Furthermore, it is attributable to the Megacephalina due to the large body with total length/width ratio 2.3:1; labium transverse, without median tooth; eyes large; prothorax noticeably narrower than elytra; anterior corners of pronotum noticeably more extended anteriorly than anterior margin of prosternum (Pearson et al., 1999). This genus resembles several genera within the subtribe Megacephalina (such as *Tetracha* Hope and *Megacephala* Latreille) in the body shape, but the latter always have a longer pronotum.

Cretotetracha grandis sp. nov. represents the earliest record of Cicindelinae, and extends the time of origin of the Megacephalina as early as the Early Cretaceous. Large mandibles and long legs suggest that *C. grandis* was clearly a large, strong predator with high running ability. Although most cicindelines (such as *Cicindela*) are diurnal and may be out on the hottest days, basal cicindelines (such as *Omus, Amblycheila*, *Tetracha,* and *Megacephala*) are all nocturnal (Pearson, 1988). Therefore, *C. grandis* was probably a night-active predator too.

More than one hundred years ago, Gissler (1879) speculated Cicindelinae had diverged during the Mesozoic. Our fossil provides robust evidence for his hypothesis, and further suggests that Cicindelinae were well diversified by the mid-Cretaceous (Pearson, 1988).

5. Concluding remarks

A new genus and species of Cicindelinae, *Cretotetracha grandis* gen. et. sp. nov., is described from the Lower Cretaceous Yixian Formation (lower Aptian). *C. grandis* is the earliest record of Cicindelinae and also the second Cretaceous specimen that can be confidently attributed to the Cicindelinae. Our analyses provides evidence that Cicindelinae had diverged during the Mesozoic and extends the time of origin of the Megacephalina as early as the Early Cretaceous.

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